PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to operating circuit arrangements for electromagnetic devices.

We, GRUNDIG E.M.V. ELEKTRO-MECHANISCHE VERSUCHSANSTALT, Inh. MAX GRUNDIG, a German corporate body, of Kurgartenstrasse 37, Fuerth/Bayern, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an operating circuit arrangement for electromagnetic devices and in particular for transistor-controlled electromagnetic devices.

It is known that the operation of solenoid valves, magnetic clutches and like electromagnetic devices can be accelerated by applying to the operating coil of the device to be actuated, at the moment of bringing it into operation, an increased voltage which, after the operation has been effected, is reduced to the normal working voltage for the device or to a lower voltage. If the voltage control is carried out by means of relays, it is easily possible at first to use double the working voltage as a supply voltage and subsequently to reduce this voltage to the normal working voltage by connecting a resistor in series with the supply. If the control is to be effected by means of transistors, however, this procedure requires that transistors are used, the inverse voltage of which amounts to double the working voltage.

The invention discloses a means which renders it possible to employ transistors of which the inverse voltage is equal to the normal supply voltage.

According to the present invention there is provided an operating circuit arrangement for an electromagnetic device wherein the operating coil of said device is connected across a direct voltage source in series with the emitter/collector path of a transistor and in series with a diode poled to allow current to flow from said source through said coil and wherein a capacitor arranged to be charged from said source through said diode is also arranged when said transistor becomes conductive to be connected by way of the emitter/collector path of a second transistor so that the voltage thereon reverse biases said diode and is added to that of said source to cause current to pass through said coil.

In this case one terminal of the capacitor may be connected both to the anode of the diode leading to one pole of the source of working voltage and to the device to be controlled and its other terminal may be connected to the collector of the second transistor, which is returned through a resistor to the other pole of the source of working voltage. The base of the second transistor is controlled in accordance with the condition of conduction of the transistor connected in the circuit of the device to be controlled. A certain disadvantages of this circuit arrangement is that the inductive voltage peak, occurring when the controlled device is disconnected, cannot be satisfactorily checked. It would, for this purpose, be possible to connect a diode in parallel with the controlled device. This would involve a delayed release, however, which cannot in every case be accepted.

It is therefore more favourable to connect one terminal of the capacitor to the anode of the diode, the cathode of which may appropriately be connected by way of the series combination of a resistor and the controlled device to one pole of the source of working voltage, and also to the collector of the first transistor, and the other terminal of the capacitor to the emitter of the second transistor and, through the series combination of a second diode and a resistor, to the other pole of the source of working voltage. The emitter and base of the second transistor are bridged by a resistor which, with a further resistor returned to the other pole of the source, forms a voltage divider which, when

the first transistor becomes conducting, also makes the second transistor conducting. The on-load voltage can be limited to half the working voltage by the resistor connected in series with the device, so that the energy stored at the moment of disconnection is considerably lower. In addition, the energy released in the member to be operated when the first transistor is cut off can immediately re-charge the capacitor so that energy recovery occurs.

Two examples of embodiments of the invention will be explained in more detail below with reference to the drawing, comprising Figures 1 and 2 in both of which the same reference numerals are used for like parts.

In the circuit shown in Figure 1, the device to be controlled — a solenoid valve MV — is connected to the neutral conductor through the emitter-to-collector path of a first transistor T_1 and to the negative pole of a -24V source of working voltage through a diode D_1. Also connected to this pole of the source of working voltage is the emitter of a second transistor T_2 of which the collector is connected through a resistor R_1 to the other pole of the voltage source and in addition to the one terminal of a capacitor C, the other terminal of which leads to the anode of the diode D_1. The base of this second transistor is connected to the collector of the first transistor T_1 through a resistor R_3; another resistor R_2 serves as a base-to-emitter leak resistance.

When the transistors T_1 and T_2 are cut off, the capacitor C becomes charged with the polarity shown through the diode D_1 and the resistor R_1. This state changes as soon as the actuating voltage is applied to the base of the transistor T_1. As a result of this applied voltage the transistor T_1 becomes conducting and also sets the transistor T_2 into the conducting state through the resistor R_3. The diode D_1 is thus reverse biased and the voltage appearing on the capacitor is added to the supply voltage and becomes effective at the solenoid valve MV, that is to say the operation of the solenoid valve is accelerated. On the discharge of the capacitor, the voltage drops and diode D_1 again becomes conductive so that the solenoid valve is run at the normal voltage after the capacitor discharge is terminated.

In the embodiment of the invention which is shown in Figure 2, the one terminal of a capacitor C is connected to a circuit leading from the collector of a first transistor T_1 and to the anode of the diode D_1 of which the cathode is connected through a resistor R_4 and a solenoid valve MV to be controlled to the negative pole of a -24V source of working voltage, and its other terminal is connected to the emitter of a second transistor T_2. The emitter of the transistor T_2 is also connected, through the series combination of a second diode D_2 and a resistor R_5, to the neutral conductor of the source of working voltage. Furthermore, there is connected from the transistor base to the neutral line a voltage divider formed by the series combination of a resistor R_6 and a resistor R_7, which form a voltage divider to the tapping of which the base of the transistor is connected. The collector connection of transistor T_2 is taken to the junction point of resistor R_4 and the solenoid valve MV.

With transistors T_1 and T_2 cut off, the capacitor C can be charged through the solenoid valve MV, the resistor R_4, the diodes D_1 and D_2 and the resistor R_5. When the transistor T_1 becomes conducting through the application to its base of an actuating voltage applied at terminal E, the terminal of the capacitor C carrying the negative potential becomes connected to the neutral conductor. There is thus applied to to base of transistor T_2 from voltage divider R_6, R_7 a voltage which causes the transistor to become conducting. Thus capacitor C is now connected in parallel with the resistor R_4 and the diode D_1 so that here, too, the voltage appearing on the capacitor C is added to the supply voltage and becomes effective on the solenoid valve MV. The solenoid valve is thus operated with double the supply voltage at the moment of energization.

As soon as the capacitor C is discharged, the voltage drop on the resistor R_8 disappears so that the transistor T_2 returns to the cut-off condition. The solenoid valve MV receives its operating current through the transistor T_1, the diode D_1 and the resistor R_4. The on-load voltage of the solenoid is reduced to a lower value, for example half the working voltage, by the series resistor R_4 so that at the moment of disconnection the stored electrical energy is negligible. When transistor T_1 is cut off, the energy released from the solenoid recharges the capacitor C through the resistor R_4, the diodes D_1 and D_2 and the resistor R_5; thus this energy is not wasted. Care must be taken to ensure that the resistor R_5 has a value such that the current flowing through it remains below the holding current for the solenoid valve.

WHAT WE CLAIM IS:—

1. An operating circuit arrangement for an electromagnetic device wherein the operating coil of said device is connected across a direct voltage source in series with the emitter/collector path of a transistor and in series with a diode poled to allow current to flow from said source through said coil and wherein a capacitor arranged to be charged from said source through said diode is also arranged when said transistor becomes conductive to be connected by way

of the emitter/collector path of a second transistor so that the voltage thereon reverse biases said diode and is added to that of said source to cause current to pass through said coil.

2. A circuit arrangement in accordance with claim 1 wherein said diode, said coil and the emitter/collector path of the first said transistor are connected in series in the order stated from a first to a second pole of said source, the emitter/collector path of said second transistor and a resistor are connected in series in the order stated from said first to said second pole, said capacitor is connected from the junction of said diode with said coil to the junction of said second transistor with said resistor and the base of said recond transistor is connected to the tapping of a voltage divider formed by resistors connecting said first pole to the junction of said coil with said first transistor.

3. A circuit arrangement in accordance with claim 1 wherein said coil, a resistor, said diode and the emitter/collector path of first said transistor are connected in series in the order stated from a first to a second pole of said source, said capacitor, a second diode and a resistor are connected in series in the order stated in parallel with the emitter/collector path of said first transistor, the emitter/collector path of said second transistor is connected from the junction of said coil with first said resistor to the junction of said capacitor with said second diode, and the base of said second transistor is connected to the tapping of a voltage divider comprising resistors connected in series between the junction of said capacitor with said second diode to said second pole.

4. An operating circuit arrangement for an elctromagnetic device substantially as described with reference to Figure 1 of the drawing.

5. An operating circuit arrangement for an electromagnetic device substantially as described with reference to Figure 2 of the drawing.

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1 SHEET

FIG. 1

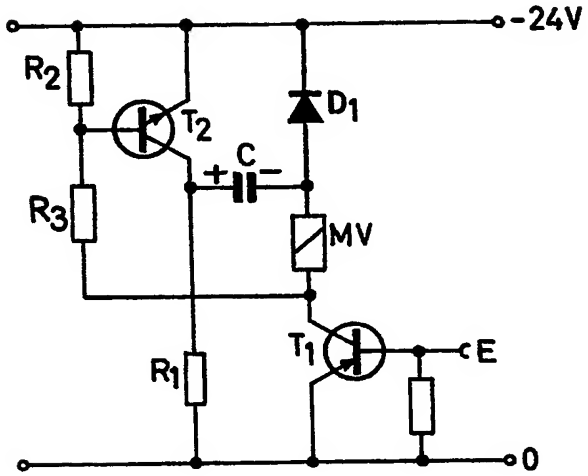

FIG. 2